A model for the shallow and intermediate depth seismic sources in the Eastern Mediterranean region

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Abstract - Seismic zones are defined as active fractured belts of the lithosphere determined principally by seismic data. On the basis of historical and instrumental data (1900-1999) from the major known earthquakes of shallow and intermediate focal depth, the main seismic zones in the Eastern Mediterranean area have been determined. Using additional data (e.g. distribution of smaller magnitude earthquakes, seismotectonic information, tsunami data) the seismic zones were divided into smaller ones and a model of seismic sources is proposed. Their seismicity parameters, which are proper for seismic hazard assessment, are given in tables.

1. Introduction

Seismic zonation and related seismicity studies are important not only for theoretical reasons (i.e. improvement in understanding of the geodynamics of a region) but also for practical reasons. Two of the most important practical problems are the seismic hazard assessment and earthquake prediction. The geographical determination of the seismic zones can be based on the distribution of the earthquake activity and the use of additional seismotectonic, geomorphological and geophysical information. The basic law, which is usually applied in studies for the parameterization of seismicity, is the Gutenberg and Richter (1944), frequency-magnitude statistical relationship. In order to apply this relationship for the determination of the seismicity in an area, the area must be seismotectonically homogeneous (similar type of faulting, common stress field, homogeneous macroseismic field, etc.). For this reason, it is necessary to use an homogeneous and complete catalogue of earthquakes and then to identify within the whole study region, seismic zones that are as much as possible seismotectonically homogeneous.

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Even though many papers and catalogues have been published on seismicity of the Eastern Mediterranean region using instrumental (1900-1999) and historical information (Ambraseys, 1965, 1989, 1992, 2000; Papazachos, 1973; Ben-Menahem, 1979, 1981, 1991; Ben-Menahem, et al., 1982; Ambraseys and Finkel, 1987, 1995; Ambraseys and Adams, 1992; Ambraseys et al., 1994; Ambraseys and Jackson 1998; Khair et al., 2000), only a few papers have been published on zonation studies (Erdik et al., 1982, 1999; Khair et al., 2000).

The present paper attempts to define a seismic source model in the Eastern Mediterranean area (30°N-39°N, 30°E-39°E) by using a recently published seismotectonic model, a homogeneous catalogue of earthquakes and other geological, and geophysical data (type of faulting, orientation of isoseismals, tsunami nucleation, topographic data). In addition, parameters for each seismic source, which are currently used as measures of seismicity and are proper for seismic hazard assessment are estimated and given in tables. The seismic zoning and the determination of seismicity parameters have been done separately for shallow and intermediate depth earthquakes. With regard to the accuracy of the seismic data used in the present study we can say that for earthquakes of the instrumental era the errors in the epicentres are less than 25 km and the errors in the magnitudes less than 0.3 magnitude units, while the corresponding errors for the historical earthquakes are higher and can reach up to 50 km in the epicentres and 0.5 magnitude units.

2. Seismotectonic setting

A prerequisite for a zonation in any area is the adoption of a reliable seismotectonic model which best describes the active tectonics of the study area. With the term active tectonics we mean the kinematic and dynamic processes of the lithosphere that take place in the area (e.g. motion of the lithospheric plates, deformation). The active tectonics can be studied using several methods (geological, geophysical, geodetic) and its measurement can be determined using several techniques. Seismicity can be one of these.

The map in Fig. 1 (Papazachos and Papaioannou, 1999) shows the examined area and its main seismotectonic features, which are the Cyprus Arc with the Paphos transform fault (PTF), the Dead Sea Transform Fault Zone (DSTFZ) and the East Anatolia Fault Zone (EAFZ). Even though there was an agreement, in previously published papers, on the role and the geometry of the East Anatolia and Dead Sea fault zones, there was not an agreement on the geometry of the Cyprean Arc and the relative motion of the plates in the area of Cyprus (McKenzie, 1970, 1972; Comninakis and Papazachos, 1972; Nur and Ben-Avraham, 1978; Rotstein and Kafka, 1982; Kempler and Ben-Avraham, 1987; Ben-Avraham et al., 1988, 1995; Ben-Avraham, 1989). Recently, Papazachos and Papaioannou (1999) proposed a model for the plate boundaries in the area of Cyprus and the qualitative description of the plate motion in the area. This model was adopted in the present study.

According to this model the boundary between the African and the Eurasian plate is formed by two arcuate structures, the eastern and western ones, which have their concave side to the north and are connected by a NNE striking transform dextral fault, the PTF, just west of Cyprus. The eastern structure consists of the Cyprean Arc and its continuation into the gulf of Adana, which then joins the Eastern Anatolian Fault. The African plate is slowly subducted under the Eurasian plate from south to north but in the Cyprean Arc the Cyprean microplate also overrides the Levantine lithosphere in a SW direction.

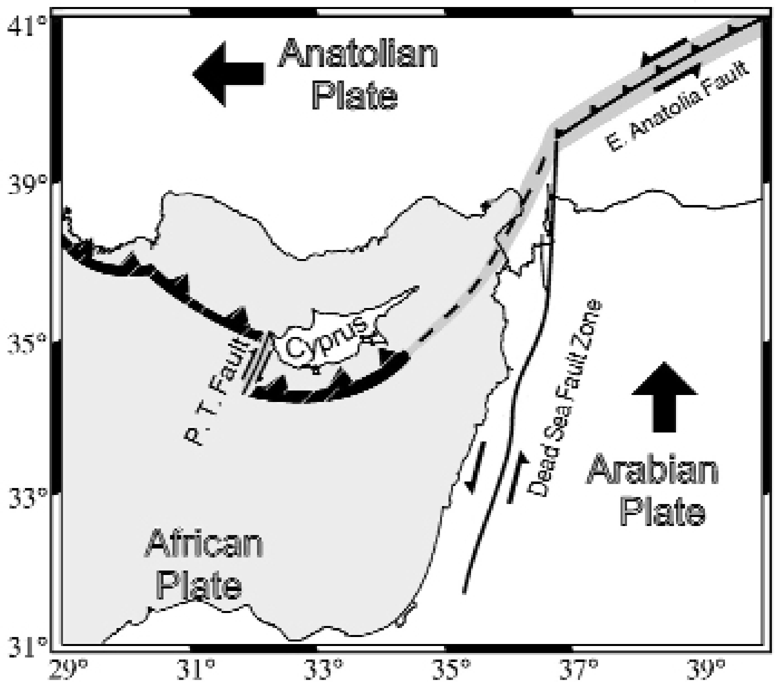

Fig. 1 - Main seismotectonic features in the Eastern Mediterranean area (Papazachos and Papaioannou, 1999). The arrows show the plates' motions.

3. Catalogue of earthquakes

The region studied involves different countries, so a global, multinational analysis of its seismicity has not been carried out up to now. Mainly, each individual country has studied it for the development of national earthquake catalogues. Moreover, in terms of earthquake magnitudes, the situation in the study area is typical in that the magnitude scales applied by different observatories and countries are nearby kaleidoscopic. In recognizing the importance of a uniform magnitude scale in the seismic zonation, an effort towards the magnitude homogenization was also done.

In order to compile a complete and homogeneous catalogue, several sources of data were used for the instrumental (1900-1999) and historical (before the 20th century) earthquakes. The most important are all the available catalogues of the international seismological agencies (ISC, NEIC, CSEM), the bulletins of the seismological networks in the area (Istanbul Kandili Observatory, Turkey, ISK; Institute of Petroleum Research and Geophysics, Israel, IPRG; National Research Institute of Astronomy and Geophysics, Helwan, Egypt, HLW; Cyprus Seismological Network, CSS; Bhannes, Lebanon, BHL) and the catalogues of Ambraseys

(1965, 1989, 1992, 2000), Karnik (1969, 1971), Comninakis and Papazachos (1978), Alsan et al. (1975), Ben-Menahem (1979, 1981, 1991), Ambraseys and Finkel (1987), Ambraseys and Adams (1992), Ambraseys and Jackson (1998) and Khair et al. (2000). Based on these sources, an homogeneous catalogue of earthquakes for the area bounded between the meridians 30 °N-39 °N and the parallels 30 °E -39 °E was compiled, which can be separated into three periods with respect to the time window covered by the data. The magnitudes of the earthquakes in this catalogue are given in a scale equivalent to moment magnitude, M^*_W (Papazachos et al., 1997).

The first time interval corresponds to the historical earthquakes (before 1900). The minimum magnitude for this period is $M^*_W = 6.0$ and their seismicity parameters were adopted using information from more than one source. A criterion for considering the parameters of any catalogue was the existence of additional information on the location of epicenters and the magnitude determination.

All the catalogues were examined and in cases of multiple entries the adopted epicenter was the weighted mean of the published epicenters, depending on the quality and quantity of information. In a few cases, for which a lot of information on the effects of the earthquakes is available, the location was re-estimated. One case was the June 22, 1896 earthquake, off shore Cyprus. In most of the catalogues, the epicenter is located in the sea and in the catalogues of Galanopoulos and Delibasis (1965) and Ben-Menahem (1991) the focal depth is denoted by 'i' (intermediate depth). The foreshock and aftershock activity of this earthquake was very long and the earthquake caused cracks in the ground and liquefaction of deposits (Ambraseys, 1992). Based on these pieces of information, the earthquake was considered as a shallow event with the epicenter near the southern coast of Cyprus (Akrotiri area, 15 km SW of Limassol). The errors in the epicenters are of the order of 30-50 km depending on the quality and amount of information. The magnitudes of the earthquakes, for this time period, are given in the various catalogues in the surface wave magnitude scale and were converted to moment magnitude according to the scaling relation $M^*_W = M_S$ holding for $M_S \geq 6.0$ as proposed by Papazachos et al. (1997).

The second interval includes the earthquakes for the period 1900-1963. The source parameters of this period were determined on the basis of instrumental records. The parameters of the hypocenters were based on the available information and the number of the stations used for the location. Moreover, for the first decades additional information (macroseismic data, sea bottom and surface topography, tsunami nucleation) was also considered and the final epicenters have errors of the order of 20 -30 km. During the third time period (1964-1999) NEIC and ISC routinely published the source parameters of the earthquakes and the body wave magnitude, m_b. Their published epicenters were adopted and the mean error in the epicenters estimation can be considered less than 20 km. The magnitude threshold considered for this period was $M^*_W = 4.0$.

In order to use the same magnitude scale for these two periods we followed the next procedure.

All the body wave magnitudes reported mainly by ISC and NEIC were converted into M^*_W according to a formula holding between m_b and M^*_w (Papazachos et al., 1997). The magnitudes in the catalogue of Karnik (1971) were converted using a scaling relation proposed by Scordilis (2001). Alsan et al. (1975) calibrated the magnitude of earthquakes in their catalogue, which is part of the ANK (Ankara) catalogue, according to the surface wave magnitude, Ms, determined by the Uppsala network. The surface wave magnitude determined by the Greek seismological centers is almost equal to the Ms determined by Uppsala. Hence, for earthquakes in their

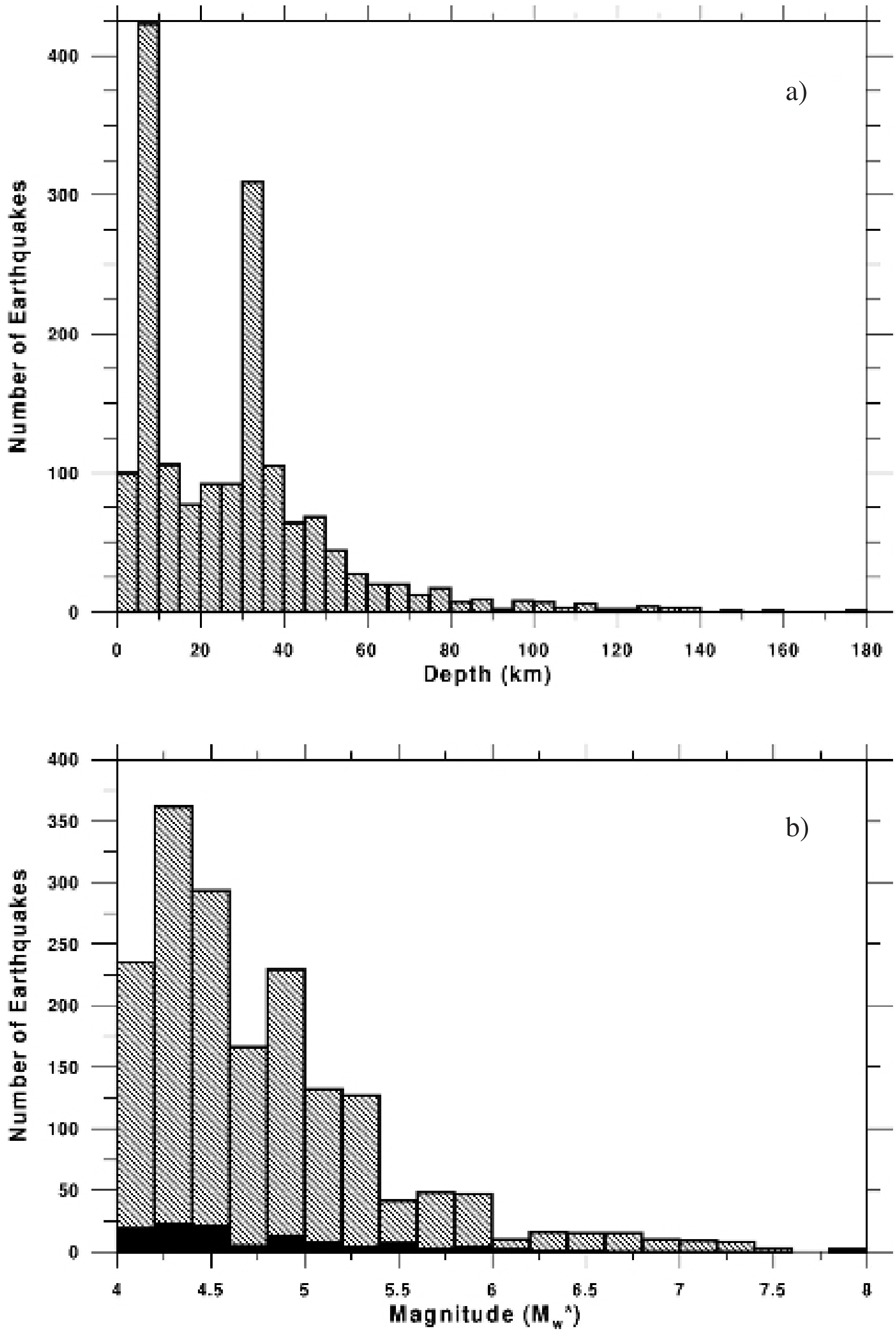

Fig. 2 - Frequency histograms for the focal depths of the earthquakes in the Eastern Mediterranean area (a) and their magnitudes (b). The two different fill patterns in Fig. 2b correspond to the frequency histograms for the shallow (slash) and intermediate depth (solid) earthquakes.

catalogue with $M_s \leq 5.9$ the relation proposed by Papazachos et al. (1997) was applied. The same relation was also applied for the data from other catalogues where the surface wave magnitude scale was used and information on the procedure used for the calculation of the magnitude exists. The magnitudes reported by ISK were converted in terms of a relation proposed by Baba et al. (2000).

In order to convert the magnitudes from the regional networks IPRG, HLW, PPCY (Paphos), BHL to M^*_W, the "local" magnitudes of the earthquakes in their bulletins were calibrated against either originally reported M_W by Harvard University (HRV) or M^*_W converted from NEIC/ISC m_b. Therefore scaling linear relations holding between the local magnitude of these networks and the equivalent moment magnitude M^*_W were found (Papaioannou, 2000). In the cases where more than one magnitude were available and there was no m_b from NEIC or ISC, the mean value of the converted M^*_W was adopted as the magnitude of the corresponding earthquake. Therefore the magnitude of earthquakes in this final catalogue is expressed in a common scale.

Fig. 2 shows the frequency histograms for the focal depths (Fig. 2a) of the earthquakes in the catalogue and their magnitudes (Fig. 2b). As can be seen from the histogram in Fig. 2a, most of the earthquakes have a depth of less than 40 km. For 466 shallow events there is no depth determination. No earthquake with depth $h \geq 40$ km was found in the convex part of the Cyprean Arc. Two different fill patterns were used in Fig. 2b for the frequency histograms for the shallow (slash) and intermediate depth (solid) earthquakes. The catalogue includes 64 shallow earthquakes for the period 2150 BC - 1896 AD in the magnitude range $6.0 \leq M^*_W \leq 7.9$. There are 1962 shallow and 132 intermediate depth (60 km $\leq h \leq$ 180 km) events in the catalogue for the instrumental period (1900-1999). The maximum magnitudes for the shallow and intermediate depth earthquakes are 6.9 and 6.5 respectively.

4. Seismic zones

Using the seismotectonic model of Papazachos and Papaioannou (1999) three main seismic zones of shallow earthquakes can be identified in the area, which are related to the main seismotectonic units in the area. These are the zone of the Cyprean Arc, the DSTFZ and the western segment of the EAFZ. A fourth zone, which is related to the intermediate depth earthquakes in the area of the Cyprean Arc, was also examined. The map in Fig. 3 shows the geographical distribution of the zones of the shallow earthquakes. The epicenters of all the earthquakes with magnitude $M^*_W \geq 5.0$ (circles), and the location of the main sites (stars) reported in the text are also shown.

In order to determine the seismicity parameters for each of the above mentioned zones, the data completeness for every one was examined by taking into account the seismicity rate above various magnitude thresholds according to a method proposed by Papazachos (1980). In order to examine the data completeness, a plot of the yearly cumulative number of earthquakes as a function of time for various magnitude thresholds is needed. The increase of the slope of the linear trend of the data points shows the time since the data are complete for magnitudes greater than, or equal to, the corresponding magnitude. It must be pointed out that the data for the periods of quiescence was not excluded in determining the seismicity rates. For this reason it is possible that in some cases the background seismicity rate has been slightly underestimated. The plots in Fig. 4 (Papaioannou, 2000) show the application of the method for the shallow earthquakes in the Cyprean Arc. The arrows show the year since the data are complete for the corresponding cut-off magnitude.

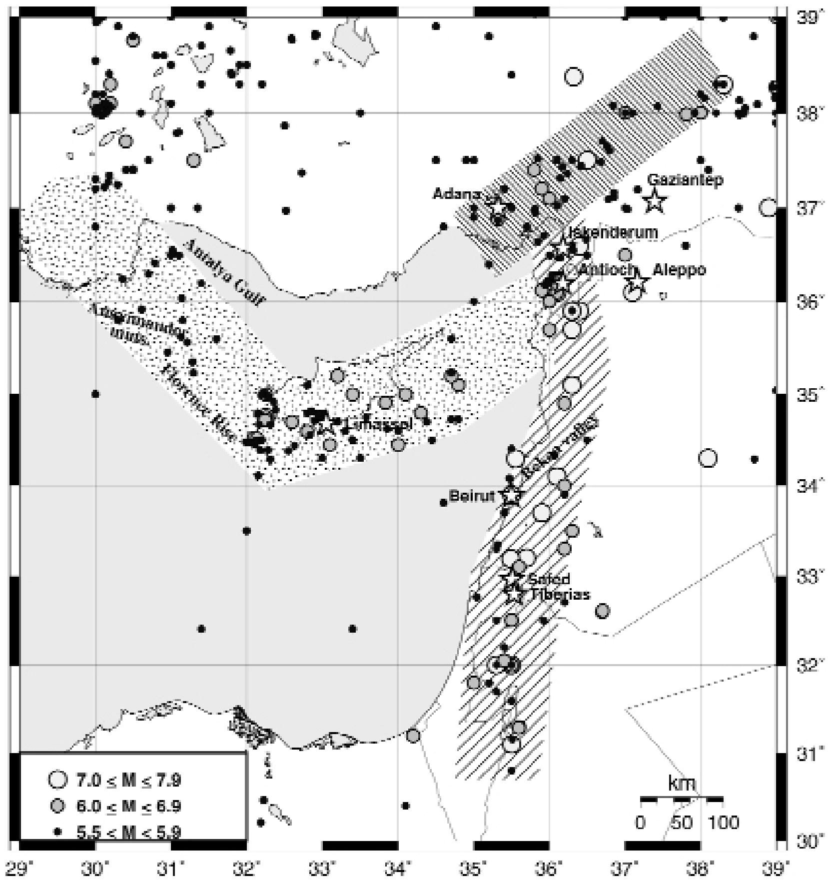

Fig. 3 - Geographical distribution of the three zones of the shallow earthquakes marked with different hatching patterns. The epicenters of all the earthquakes with magnitude $M^*_W \geq 5.0$ are also shown. The stars and the names next to them stand for the location of the main cities, reported in the text, and their names.

Table 1 summarizes the information on the completeness of the earthquake catalogue, that is the year and the corresponding minimum magnitude, above which the data are complete, and are given for each seismic zone. Using these completeness criteria for every zone the number of earthquakes for every magnitude class were normalized to the maximum time period for which the data are complete. It means that the number of observed data was multiplied by the factor: $t/(1999-t_i)$, where t is the largest number of years covered by the complete data which is given for every zone in Table 1 and t_i is the starting year of each subinterval for which the data are complete for magnitude $M^*_W \geq M_i$ (e.g. for the Cyprean Arc Zone the number of earthquakes with magnitude $M^*_W \geq$ 4.0, 4.1, …4.4 in the time window of 12 years (1999-1987), was

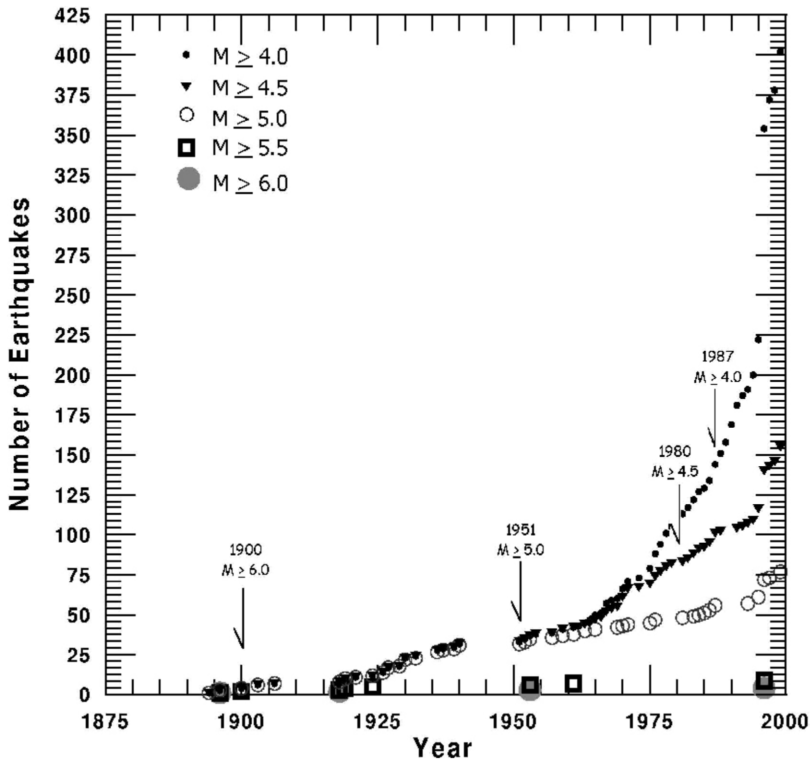

Fig. 4 - Seismicity rates for the shallow earthquakes in the Cyprean Arc for various magnitude thresholds. The arrows indicate the year from when the data are complete for the corresponding cut-off magnitude (Papaioannou, 2000).

multiplied by the factor 103/12). The last column in Table 1 gives the estimated values of the parameters *b*. Fig. 5 shows the cumulative frequency-magnitude plots for the four zones. As it can be observed from Table 1, for the zones of the Cyprean Arc and the EAFZ the calculated

Table 1 - Information for the three main seismic zones of shallow and one of intermediate depth earthquakes on the completeness of earthquake data, the time covered by the complete data, *t*, and the parameter *b*.

Cyprean Arc								**t**	**b**
1987	1980	1951	1900	1896				103	1.12
4.0	4.5	5.0	6.0	6.5					
East Anatolia Fault Zone									
1975	1944	1926	1908	1893	1513			486	1.03
4.0	5.0	5.5	6.0	6.5	6.5				
Dead Sea Fault Zone									
1970	1951	1927	1900	1546	1202	1157	551	1448	0.78
4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5		
Intermediate Depth Earthquakes									
1981	1964	1924	1911					88	0.94
4.0	5.0	5.5	6.0						

values of the parameter *b* were found to have similar values. The maximum magnitudes for these zones, as they have been estimated from historical earthquakes, also have similar values. A smaller *b* value was determined for the DSTFZ, which is related to the significant number of strong ($M^*_W \geq 7.5$) earthquakes. In this zone there are quiescent periods with a duration of up to a few centuries alternating with periods of high seismic activity which last several decades (Khair et al., 2000). The maximum magnitude for this zone is $M^*_W = 7.9$. This complex long and extensive zone is the area of the relative motion of the Arabian Plate with respect to the African Plate, where there is a compressional deformation with a mean velocity 1 cm / yr in N-S direction (Kiratzi and Papazachos, 1995; Reilinger et al., 1997). The b-value for the zone of the

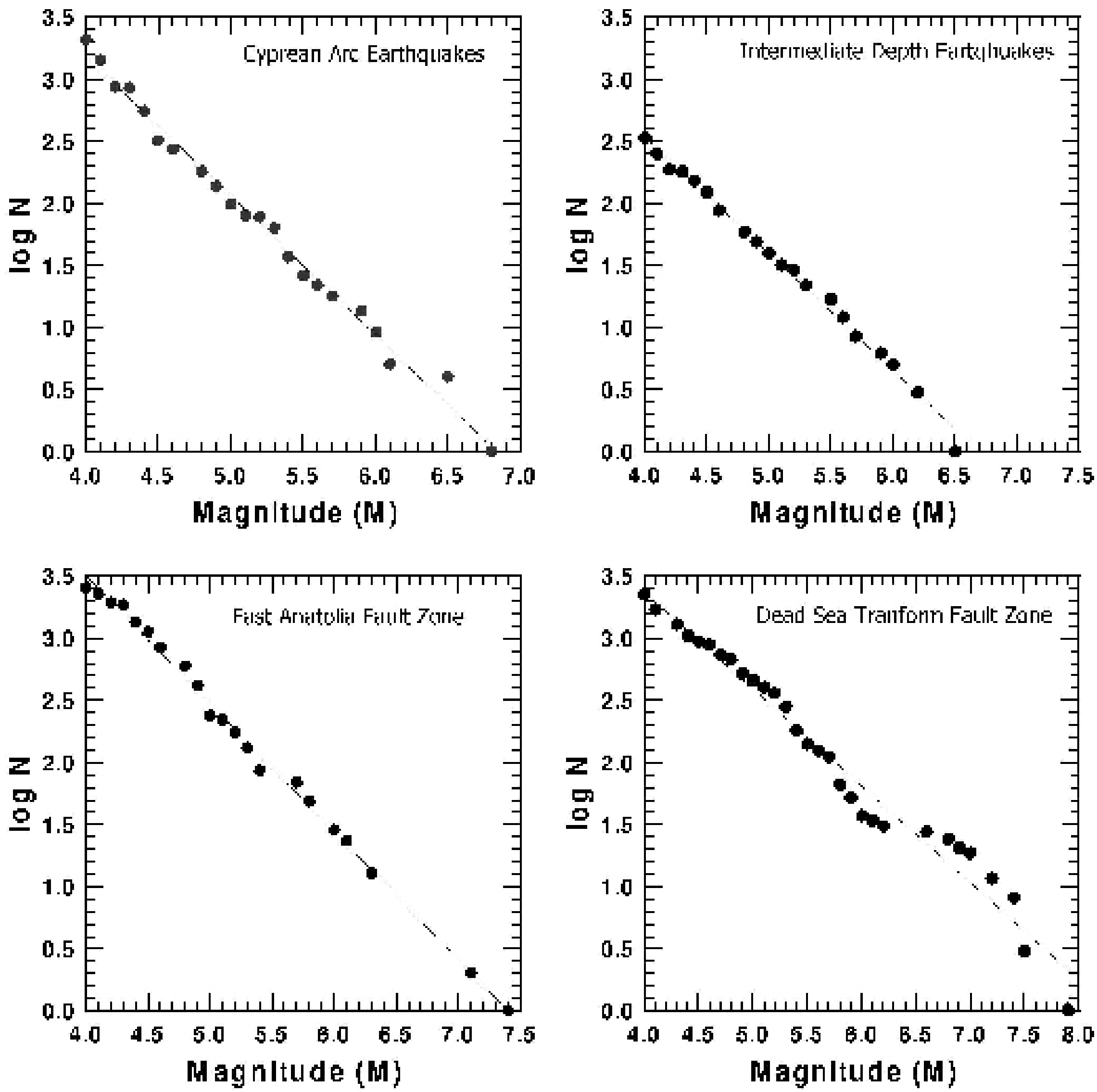

Fig. 5 - Magnitude distribution of the normalized complete set of earthquakes for the three seismic zones of shallow earthquakes and the one of intermediate depth earthquakes.

intermediate depth earthquakes is higher than those which have been calculated for the Hellenic Arc (Papazachos, 1990; Papazachos and Papaioannou, 1993). This is probably due to the large magnitudes of the earthquakes in the Hellenic Arc.

Based on the distribution of seismic activity shown in the map of Fig. 3 and using all the available information (maximum magnitude, b-value, seismotectonic environment, topography) the three seismic zones of the shallow earthquakes where separated into smaller ones called seismic sources. Using the same procedure three seismic sources of intermediate depth earthquakes were also identified. Such seismic sources are appropriate for any seismic hazard

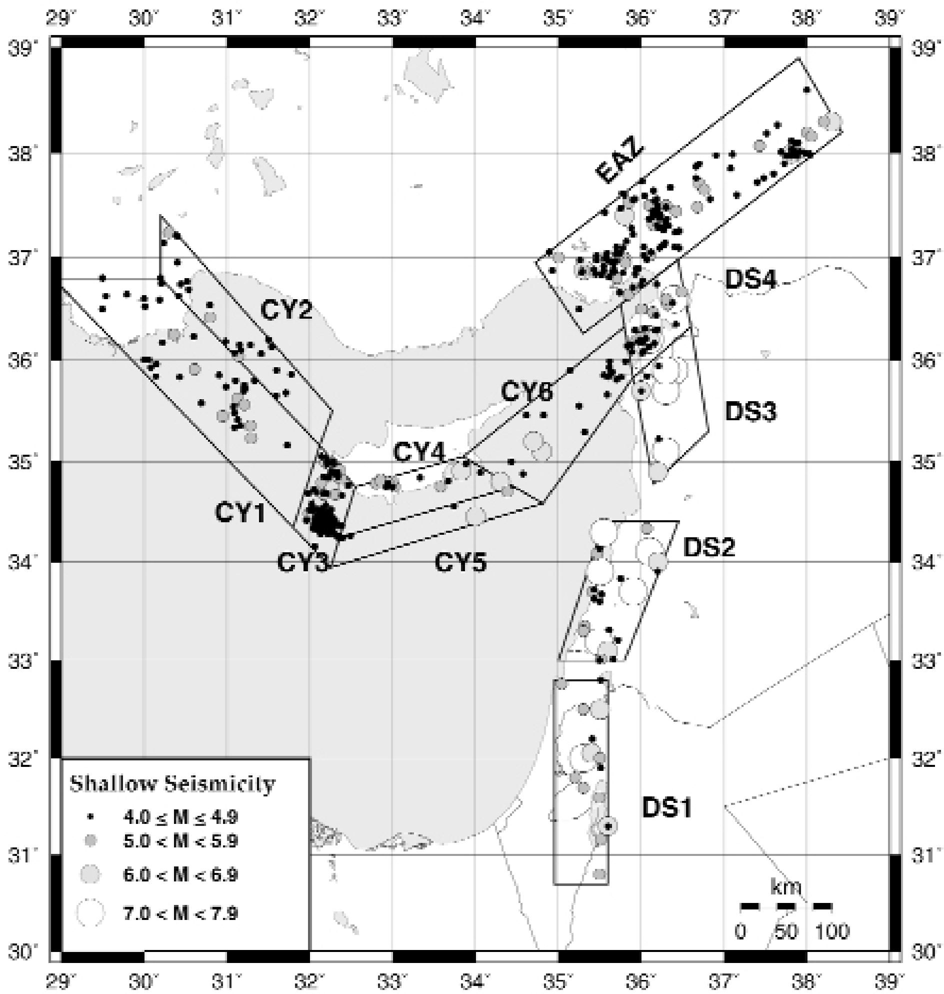

Fig. 6 - Seismic sources of shallow earthquakes in the Eastern Mediterranean area. The earthquakes within them that satisfy the completeness criteria of Table 1 are also shown.

application. Their seismicity parameters can be determined by applying the constant b-value of the corresponding seismic zone to the complete set of earthquakes in every one of them. The seismic sources of shallow earthquakes are shown in the map of Fig. 6. The complete data of every source are also plotted. Information on these sources are given below.

4.1. Cyprean Arc seismic sources

The shallow earthquakes along the Cyprean Arc can be associated with six sources of shallow earthquakes (Fig. 6).

The first two zones (CY1 and CY2) of shallow earthquakes are located northwest of Cyprus and are related to the north-eastern part of the arc. They start from the northern end of the PFT, include the Florence rise and continue north-west up to the north-eastern end of the Anaximander Mountains. Both the zones are of low seismicity and the maximum observed magnitude of earthquakes in these sources is 5.5. According to Papazachos and Papaioannou (1999) thrust faults dipping to north-west (to Antalya Gulf) are expected here. On the western coast of Cyprus the next source (CY3), which strikes in a NNE direction and is associated with the PTF (Papazachos and Papaioannou, 1999). Two earthquakes (1953, M = 6.5; 1996, M = 6.8) and the earthquake of 1995, M = 5.9, out of the five strong (M > 6.0) shallow earthquakes, which affected Cyprus during the last century, occurred in this source. There are also at least three known destructive historical earthquakes (15 BC, 342 AD, 1183) which may have been generated by this fault and have magnitudes up to about 7.0, which was considered as the maximum magnitude of this source.

Three sources were identified in the eastern segment of the Cyprean Arc. Two sources are located on the southern coast of Cyprus (CY4, CY5), parallel to the coasts and the third (CY6) continues northeastwards to join the northern end of the Dead Sea fault zone. The strong (M = 6.5) earthquake of June 1896, two other strong earthquakes (1924 M = 6.0; 1961 M = 6.0) and the last earthquake of August 1999 (M = 5.8), which caused damage in the area of Limassol, occurred in the source CY4. The earthquake of January 1900 (M = 6.1) is located in the source CY5, which is less active than CY4. Finally, the zone CY6 includes the earthquakes of 1918 and 1919 with magnitudes M = 6.5 and 6.0, respectively. According to Papazachos and Papaioannou (1999) these sources belong to a compressional (thrust) area, which may extend further, northeastwards. Even though Erdik et al. (1982, 1999) attempted a seismic zonation of the area of Cyprus, it seems that their proposal is at a very large scale and does not follow the seismicity pattern in the area.

4.2. The Dead Sea Transform Fault Zone seismic sources

Along the DSTFZ four seismic sources (DS1, DS2, DS3 DS4) were determined. Extended information on historical earthquakes can be found in Ben-Menahem (1991) and there are reports on earthquakes since the 21^{st} century BC. The b-value for this zone was found equal to 0.78, which is in agreement with the value 0.86 found by Ben-Menahem (1991). There is one fault plane solution from HRV for an earthquake that occurred on April 1979 south of the Dead Sea, which shows a nodal plane striking almost N-S.

The first (DS1) includes the Jordan river valley that extends along the central and northern part of the Dead Sea, striking almost straight in a N-S direction. The strongest earthquake that satisfies the completeness criteria occurred in 1546 (M = 7.0; Ben-Menahem, 1991) and caused great damage in the area. Most of the epicenters are located in the eastern part of this source. The source DS2 covers the Bekaa valley area. It strikes in a NE direction following the direction of the mountains and the rivers in the area. It does not exhibit high seismic activity during the last century but many earthquakes with magnitude higher than 7.0 during the previous centuries. The last strong earthquake occurred in 1837 with magnitude M = 7.0 and destructed Safed and Tiberias (Ben-Menahem, 1991). The third zone (DS3) includes the Gharb segment. It strikes in a NW direction and is characterized by the Gharb graben. Earthquakes with magnitude greater than 7.0 occurred in the 12th, 15th and 18th centuries during short periods of paroxysmal activity, and it seems that the whole 350 km long plate boundary was broken (Ambraseys and Barazangi, 1989). The source of the Kara-Su segment (DS4) includes the northern part of the DSTFZ, which is very complicated because it represents the meeting point of the African, Arabian and Anatolian plates. The old cities of Antioch, Aleppo suffered great damage many times. Questions exist on the evaluation of the information due to the 1822 earthquake. Even though in some catalogues (Karnik, 1971; Ben-Menahem 1991) there are notes on tsunami observation in Cyprus, Iskenderun and Beirut, Ambraseys (1989) wrote that there is no evidence that this event was associated with a seismic sea-wave. But he also mentioned that the shock was felt by ships sailing up to halfway between Alexandria and Cyprus. It is possible that the epicenter was closer to the coast (Antakya) than to Aleppo and Gaziantep and the rupture propagated towards them. The sea bottom bathymetry at the coast close to Antakya is very steep with a high

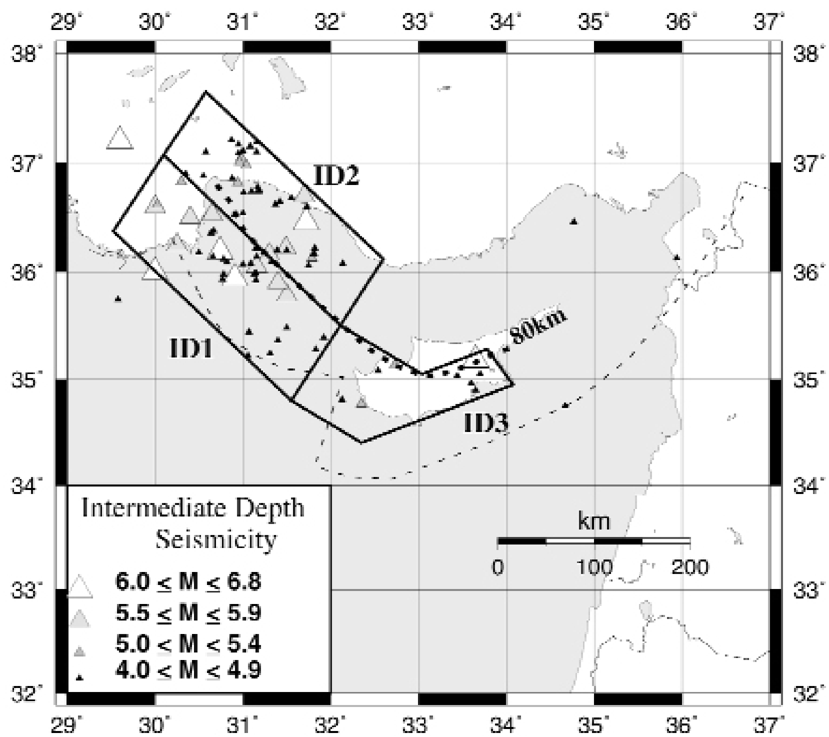

Fig. 7 - Geographical distribution of the intermediate depth earthquakes in the Cyprean Arc. The seismic sources are also shown. The dashed lines represent the isodepth of 80 km (thick) and the plate boundaries (thin) in the area (Papazachos and Papaioannou, 1999).

gradient, which can support the nucleation of a weak tsunami. A strong earthquake occurred in April 859 with M = 7.9 (Khair et al., 2000), which caused total destruction of Antioch. Damage was also caused as far as Jerusalem (Ben-Menahem, 1991).

4.3. The East Anatolia Fault Zone

The EAFZ west of 38 °E was considered as one source (EAZ in Fig. 6). The seismicity in this region extends over a broad zone as might be expected in an area of continental convergence (Rotstein and Kafka, 1982). It includes the fault segments (FS) FS9-FS14 according to Barka and Kadinsky-Cade (1988). Some of these segments are not very active and there is no evidence for the occurrence of strong earthquakes on them. The relative motion of the Arabian Plate in respect to the Plate of Anatolia is taking place in this zone, on the left-lateral strike-slip fault of East Anatolia, where there is deformation of a narrow zone with length of the order of about 250 km with a mean horizontal velocity of 4-7 mm/yr (McKenzie, 1972, 1978; Kiratzi and Papazachos, 1995; Sengor et al., 1985; Reilinger et al., 1997; Barka and Kadinsky-Cade, 1988). The last big earthquake occurred in 1822 M = 7.2. This zone terminates at the area of the 1997 Adana earthquake.

4.4. Intermediate depth seismic sources

The map of Fig. 7 shows the three sources (ID1, ID2 and ID3) of intermediate depth earthquakes. The triangles denote the epicenters of all the known intermediate depth earthquakes in the area.

Two of the sources (ID1 and ID2) are associated with a dipping Benioff zone from southwest to northeast in the Antalya Gulf area (Papazachos and Papaioannou, 1999). The source ID1 is associated with the shallow (60-80 km) part of this zone while the source ID2 reflects activity at the deeper part (80-130 km) of the Benioff zone. The third zone (ID3) includes the intermediate depth earthquakes at the area of Cyprus. Their depths do not exceed 80 km. In order to compile the model of these sources the isodepth of 80 km proposed by Papazachos and Papaioannou (1999) was used. In the model of Erdik et al. (1982, 1999) there is no zonation for the intermediate depth earthquakes.

5. Conclusions

The present paper attempts to contribute in the determination of the seismic sources of shallow and intermediate depth earthquakes in the area of the Eastern Mediterranean using an homogeneous catalogue of earthquakes. Especially for the intermediate depth earthquakes, this is the first attempt to develop a source model.

The geometry of the seismic sources was determined by the distribution of the earthquakes, the seismotectonic setting and the geomorphological information. Even though it is not possible to exclude the probability of a strong earthquake outside them, nevertheless this occurence seems rather low. On the other hand the use of extended sources in any hazard assessment study increases the results in areas of low seismicity and decreases the results for sites within them, as the value of the parameter normalized to a surface unit becomes smaller.

Table 2 - Information on the seismicity parameters of the seismic sources in the Eastern Mediterranean area (see text for details).

Code	a*	Surface, A, (in 10,000 m^2)	a_0	Rate, r, $M \geq 5.0$	observed M_{max}	Moment Rate M_o	M_C
Seismic Sources of Shallow Earthquakes							
CY1	6.77	2.66	4.33	0.054	5.5	0.132E + 24	4.7
CY2	6.55	1.09	4.50	0.080	5.5	0.194E + 24	4.8
CY3	7.41	0.50	5.70	1.249	7.0	11.300E + 24	6.0
CY4	6.80	0.80	4.89	0.193	6.5	1.126E + 24	5.3
CY5	6.46	0.64	4.64	0.110	6.1	0.417E + 24	5.0
CY6	6.78	1.46	4.60	0.100	6.5	0.586E + 24	5.1
DS1	5.93	1.48	2.60	0.050	7.0	1.141E + 24	5.3
DS2	6.05	1.26	2.79	0.077	7.5	4.040E + 24	5.7
DS3	5.89	0.85	2.80	0.079	7.4	3.501E + 24	5.6
DS4	6.07	0.57	3.16	0.180	7.9	18.300E + 24	6.1
EAZ	7.62	3.99	4.33	0.152	7.2	2.091E + 24	5.5
Seismic Sources of Intermediate Depth Earthquakes							
ID1	5.13	2.34	2.82	0.013	6.2	0.066E + 24	4.5
ID2	5.14	1.97	2.90	0.016	6.0	0.062E + 24	4.5
ID3	4.73	1.92	2.50	0.006	6.5	0.047E + 24	4.4

Using constant value for the parameter *b* of the magnitude distribution, for every source the seismicity parameters, which are useful for seismic hazard studies, were calculated and the results are shown in Table 2. These are the value of the parameters a*, and a_0 normalized to one year and for a surface unit of 10,000 km^2, the annual rate of earthquakes with magnitude $M \geq 5.0$, the maximum observed magnitude, M_{max}, the annual released seismic moment, M_o, and the corresponding earthquake magnitude, M_c. The code name of the sources shown in the maps of Figs. 6 and 7 is given in the first column of Table 2. As can be seen from this table, the most active source in the area is the PTF source (CY3). The high activity of the source DS4 is due to the high magnitude M = 7.9 of the earthquake of 859, which was adopted as the maximum magnitude for this source. However, it is important to notice that almost all the sources with high maximum magnitudes are characterized by paroxysmal activity with long periods of quiescence. The moment rate released by the intermediate depth earthquakes and the corresponding maximum magnitudes are less than those released by the shallow events.

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